1976

Small independent action force (SIAF) vegetation classification study.

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Naval Postgraduate School

SMALL INDEPENDENT ACTION FORCE (SIAF)
VEGETATION CLASSIFICATION STUDY

Wayne Everett Deutscher

NAVAL POSTGRADUATE SCHOOL

Monterey, California

THESIS

SMALL INDEPENDENT ACTION FORCE (SIAF)
VEGETATION CLASSIFICATION STUDY

by

Wayne Everett Deutscher

March 1976

Thesis Advisor: J. K. Arima

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)

Small Independent Action Force (SIAF) Vegetation Classification Study

5. TYPE OF REPORT & PERIOD COVERED

Master's thesis (March 1976)

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)

Wayne Everette Deutscher

8. CONTRACT OR GRANT NUMBER(s)

9. PERFORMING ORGANIZATION NAME AND ADDRESS

Naval Postgraduate School
Monterey, California 93940

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS

11. CONTROLLING OFFICE NAME AND ADDRESS

Naval Postgraduate School
Monterey, California 93940

12. REPORT DATE

March 1976

13. NUMBER OF PAGES

62

14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)

15. SECURITY CLASS. (of this report)

Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Small Independent Action Force (SIAF), Vegetation, intervisibility, camouflage, terrain, paired comparison, judgment, interclass correlation coefficient.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This study was conducted to examine the Small Independent Action Force (SIAF) Model's vegetation classification scheme. The SIAF Model has as its basis an ordinal scale based upon density and type of vegetation. An interval scale based upon individual judgments was established which did not correlate with the model's scale in two instances. SIAF Class 6 was judged more difficult than SIAF Class 4. An attempt was made to

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(Page 1) S/N 0102-014-6601 |

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20.

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SMALL INDEPENDENT ACTION FORCE (SIAF)
VEGETATION CLASSIFICATION STUDY

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SUBMITTED IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE IN OPERATIONS RESEARCH

FROM THE
NAVAL POSTGRADUATE SCHOOL
MARCH 1976

ABSTRACT

This study was conducted to examine the Small Independent Action Force (SIAF) Model's vegetation classification scheme. The SIAF Model has as its basis an ordinal scale based upon density and type of vegetation. An interval scale based upon individual judgments was established which did not correlate with the model's scale in two instances. SIAF Class 6 was judged as most difficult with respect to intervisibility and SIAF Class 3 was judged more difficult than SIAF Class 4. An attempt was made to determine how well an individual could determine the classification of a scene utilizing the existing SIAF Classes. Results indicated that individuals attained a correct response of 43.6%. It was also determined that there was negative intraclass correlation using the Intraclass Correlation Coefficient. No prediction can be made as to how an individual would respond to identical stimuli. There was found to be no learning effect by the subjects in determining correct SIAF Class discriminations.

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I. INTRODUCTION

New importance is being attached to current and future United States Army capabilities in the tactical and technical problem areas of camouflage and countersurveillance. These capabilities have as their purpose the denial or degradation of hostile surveillance of friendly forces so as to deny, degrade, deceive, delay or otherwise interfere with enemy target acquisition or analysis of information about these forces.

Current capabilities to systematically predict and improve visual target acquisition performance are severely limited by the lack of parametric data to define the effects of operational target-background differences. The embeddedness of the target in its natural setting has a pronounced effect on the ability of an individual to search out and acquire the target during an engagement.

Frequently the ability to detect and identify targets depends not only upon the characteristics of the targets but also upon the characteristics of the backgrounds in which they appear. In the latter case, the visual complexity of the target-background itself contributes to the difficulty of locating targets, i.e., it is more difficult to find a particular target in some backgrounds than it is in others.

The research presented here is aimed at investigating the Small Independent Action Force (SIAF) Model Vegetation Classification Scheme with respect to subjective judgments made by individuals based upon density of vegetation within each SIAF Class. The existing SIAF Classification Scheme presently being used is an ordinal scale based upon density of grass, brush, and trees, and since observers use a discriminal process when presented a stimulus such as a

vegetation scene, an interval scale based on the judgments of subjects will be established. Also, a determination of how well an individual can make use of the existing SIAF Classes for classifying vegetation scenes will be made.

II. BACKGROUND and PURPOSE

In recognition of the increasing importance and complexity of small military patrols in low intensity guerrilla warfare, Advanced Research Projects Agency (ARPA) activated the Small Independent Action Force (SIAF) program in 1968. The continued project had as its ultimate objective the improvement of the operational effectiveness of SIAF units.

The approaches considered for the SIAF model included an analytic model, war gaming and computer simulation. During the initial evaluation, a purely analytic model was discarded since it did not have the generality necessary to meet the project requirements. War gaming is too slow and unwieldy for most SIAF purposes and is usually valuable only if copious resources and time are available. Field exercises and combat testing were also considered but were ruled out since, at times, conceptual systems must be studied by the decision maker. Simulation using analytical submodels was judged to combine the necessary generality and flexibility with acceptable speed and economy. The computer simulation method allows for comparing alternative concepts (i.e., different mixes of personnel, material, and procedures) within a scenario of fixed conditions and assumptions.

In identifying the submodel areas, an effort was made to develop a model which was as realistic as possible. To this end, it was recognized that in the real world a patrol leader prepares an operations plan before he starts the mission. In this operations plan, he considers support, supply maintenance, human maintenance, communications, and command and control. In addition these are the essential functions the patrol leader performs during the execution of the plan. Hence, these areas, in addition to terrain,

weather, and enemy, were identified as the major areas for such a model development. See Figure 1 for submodels included in the SIAF Model.

Although submodels in each of these areas could conceivably be independently developed, a realistic simulation of patrol operation must also consider the interactions of the functions shown in Figure 1 with each other and the weather, terrain, and enemy situation. For example, the movement rate a patrol selects will be a function of the terrain and the weather, pack weight, and fatigue of the patrol members. This will have an impact on the patrol duration,distance traveled, the visual detection capability of the patrol, and the possibility that the patrol is detected. That is, if the patrol moves rapidly more attention must be devoted to surveillance. In addition, movement is a cue for visual detection and, hence, increases the possibility of detection by the enemy. This patrol movement rate also influences the energy expenditure rate of the patrol and the food and water requirements which are functions of the temperature and humidity and which, in turn, influence subsequent patrol movement rates. These are examples of the complex interactions which are considered in this model.

The purpose of the SIAF Terrain Submodel is to provide a representation of the terrain for use in line-of-sight and slope calculations and for considering factors such as the vegetation at various points in the area of operations as required by other subroutines. This submodel considers the following factors:

Relief

Vegetation

Obstacles and cultural features

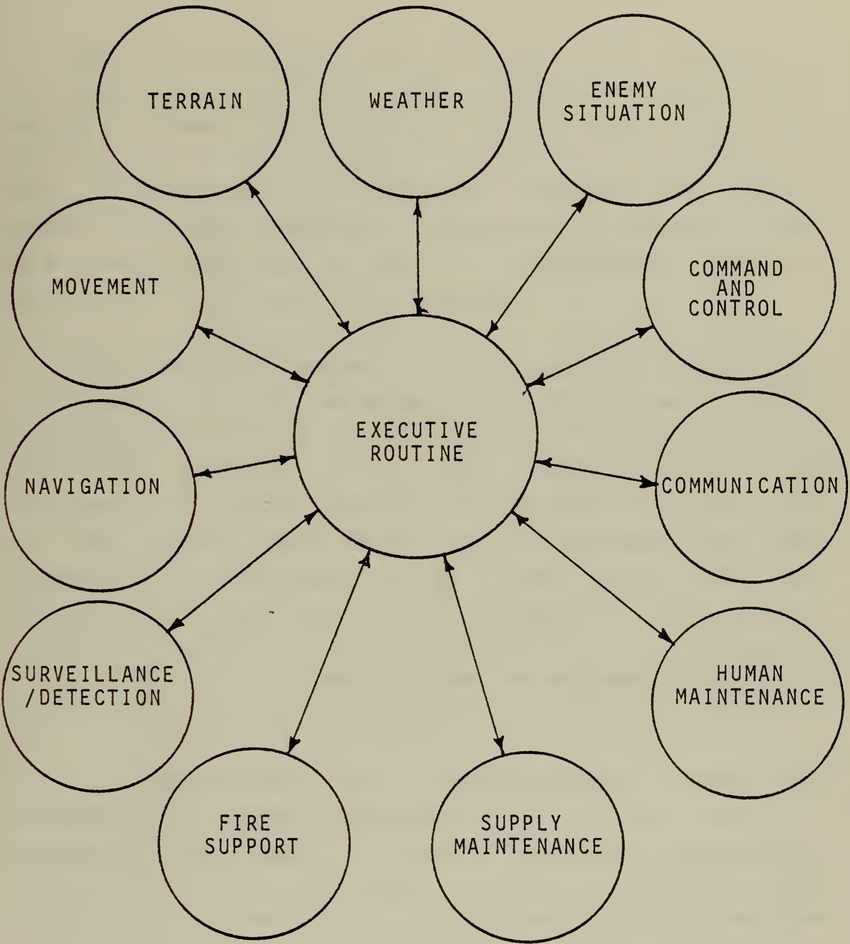


Figure 1. SIAF Model Elements

Micro-relief

Surface materials

This experiment deals only with the data required by the Vegetation Subroutine. The problem of appropriately modeling the vegetation factor of terrain for the SIAF model was approached in two-steps. First, it was necessary to develop an appropriate vegetation classification scheme. Second, it was necessary to determine the manner in which this scheme could best be used, in conjunction with the relief portion of the Terrain Submodel.

The vegetation classes considered by this submodel are shown in Figure 2. As shown in the figure, each class of vegetation consists of a certain amount of grass, brush, and trees. The features within each class are assumed to be distributed at random. Vegetation elevation for a given area is input as one number from 1 to 12 to represent the class (dominant) of vegetation to be found within the area. Exceptions to this are input as subareas in the form of triangles, circles, and rectangles and are also assigned a number from 1 to 12 and are used to represent subareas of vegetation other than the dominant within the total area.

In developing this classification scheme, TRW attempted to include consideration of the types of vegetation which might be found in the various parts of the world. An attempt was made to gather realistic data concerning the density and size of the vegetation features within each class.

It is apparent that a key factor in obtaining input data for the Vegetation Subroutine of the Terrain Submodel is the ability of an individual to discriminate density and

SIAF CLASS	FEATURE	DENSITY PER 50m x 50m	WIDTH (meters)	HEIGHT (meters)	DESCRIPTION
1	---	---	---	---	OPEN
2	GRASS OR BRUSH	300	1.0	1.0	SPARSE GRASS
3	GRASS OR BRUSH	500	1.5	1.5	MODERATE GRASS
* 4	GRASS ONLY	72	10.0	3.0	DENSE GRASS
5	GRASS	0	---	---	LIGHT FOREST WITH BRUSH
	BRUSH	63	2.0	3.0	
	TRUNK	42	0.3	2.0	
	CROWN	---	3.0	10.0	
6	GRASS	0	---	---	SPARSE FOREST
	BRUSH	150	1.0	1.0	
	TRUNK	84	0.3	3.0	
	CROWN	---	3.5	12.0	
7	GRASS	0	---	---	MODERATE FOREST
	BRUSH	300	1.0	1.0	
	TRUNK	180	0.3	5.0	
	CROWN	---	4.0	15.0	
8	GRASS	0	---	---	HEAVY FOREST
	BRUSH	0	---	---	
	TRUNK	360	0.45	9.0	
	CROWN	---	4.5	20.0	
9	GRASS	0	---	---	DENSE BRUSH WITH TREES
	BRUSH	720	2.0	2.5	
	TRUNK	18	0.2	1.0	
	CROWN	---	4.0	15.0	
*10	BRUSH	150	2.0	3.0	SPARSE JUNGLE
	TRUNK	120	0.3	7.5	
	CROWN	---	4.0	18.0	
*11	BRUSH	300	2.0	3.0	MODERATE JUNGLE
	TRUNK	210	0.3	11.0	
	CROWN	---	4.5	24.0	
*12	BRUSH	600	2.0	3.0	HEAVY JUNGLE
	TRUNK	240	0.45	14.0	
	CROWN	---	5.0	30.0	

* Not Available in Area

Figure 2. SIAF Vegetation Classifications

type of vegetation and to correctly apply the Vegetation Classification Scheme devised. Without a realistic aid to assist an individual in determining the correct SIAF Class, it is nearly impossible to correctly classify terrain in the field with any acceptable consistency. The existing metric requires the individual to either physically count the number and type of vegetation in the 50 meter by 50 meter square or make a calculated guess.

The purpose of this experiment is twofold. First, to obtain a interval scaling of the vegetation classification scheme with respect to intervisibility of the given vegetation scene. Second, to determine how well an individual can discriminate between the SIAF Classes given representative images of the Vegetation Classification Scheme. In conjunction with this the reliability of subjects will be obtained.

III. METHOD

A. EXPERIMENTAL DESIGN.

The experiment involved a continous stream of stimuli. Phase 1 stimuli were presented in pairs and the method of paired comparisions was used to obtain the interval scale. It was first introduced by Cohen(1894) in his study of color preferences. This method which was further developed by Thurstone(1927), is often regarded as the most appropriate method of securing value judgments. The subject's task is simplified by giving him only two stimuli to compare at a time. Paired comparisons is essentially a generalization of the method of constant stimuli with the two-category case. In the method of constant stimuli, each stimulus is compared with a single standard. In the paired comparison case, each stimulus in turn serves as the standard. Each stimulus is paired with each other stimulus in a randomly ordered matrix of pairs. Each is presented to the subject, whose task is to indicate which member of the pair appears greater (most difficult) with respect to the attribute to be scaled. The subject must designate one of the pair as greater. No equality judgments are permitted.

In order to obtain data from which proportions may be estimated, it is necessary for a large number of comparisons to be made of each pair of stimuli.

In the usual form the method of paired comparisons does not permit a stimulus to be compared with itself. It is assumed that, if such judgments were obtained, proportions of 0.50 would result.

No explicit provision is made for time or space errors in the law cf comparative judgment, nor is there provision

for changes in performance due to fatigue or practice effects or for judgments based in part on factors other than the relative magnitudes of the discriminal processes. Therefore, it is necessary to control experimentally the conditions that might introduce these biasing effects. These factors can be controlled in the assignment of the relative positions of the members of each stimulus pair and the order of presentation of the pairs themselves. Control by randomization of relative positions and of orders is usually adequate for many problems stated.

The method of pair comparison can be applied to any stimulus material for which pairs can be presented.

Subjects used the Direct Rating Method in Phase 2. Each subject was required to rate the stimulus presented based on his judgment of how he perceived the terrain with respect to intervisibility.

B. SUBJECTS.

Twenty volunteer male military officers assigned to the Naval Postgraduate School (NPS) participated in the experiment. They consisted of 12 Naval Officers and 8 Army Officers. The age of the subjects ranged from 26 years to 34 years. There was no criterion measure used in the selection of the subjects. The 20 subjects were randomly divided into two groups of 10 subjects each for ease in observing photographic stimuli.

C. APPARATUS.

Two Kodak Ektagraphic Model B slide projectors were used for 2 inch x 2 inch slide projection. The projectors were controlled by a Lafayette 5040A timing device which operated the projectors at syncronized 15 second intervals

for Phase 1 and 30 second intervals for Phase 2 of the experiment.

All experimental trials were conducted in facilities at the Naval Postgraduate School, Monterey, California. The room size requirements, accessory materials, and physical layout are shown in Figure 3.

D. STIMULUS MATERIAL.

To obtain the required photographic stimulus a 35mm Nikkormat camera was used with a 400mm Bushnell f/6.3 lens. Photographic imagery was processed as color negatives and formatted as 2 inch x 2 inch slides. The sample of imagery used in the experiment consisted of the following:

1. Four (4) site locations from each of 8 SIAF Vegetation Classes used in this experiment, for a total of 32 sites. Only 8 SIAF Classes were used in this experiment. SIAF Classes 4, 10, 11, and 12 were not used due to the lack of vegetation type and density in the Central California area. For ease in presentation the SIAF Classes were renumbered 1 thru 8 consecutively for the experiment.

2. One (1) site location of the 8 SIAF Vegetation Classes was selected as representative of each class and 14 copies of the scene were made to conduct Phase 1 of the experiment.

3. Phase 2 imagery consisted of 8 SIAF Classes with 3 different site locations for each SIAF Class. The scenes were randomly presented to the subjects. A total of 26 slides was used in Phase 2.

4. Two (2) slides from Hunter-Ligget Military Reservation were included for statistical consistency tests.

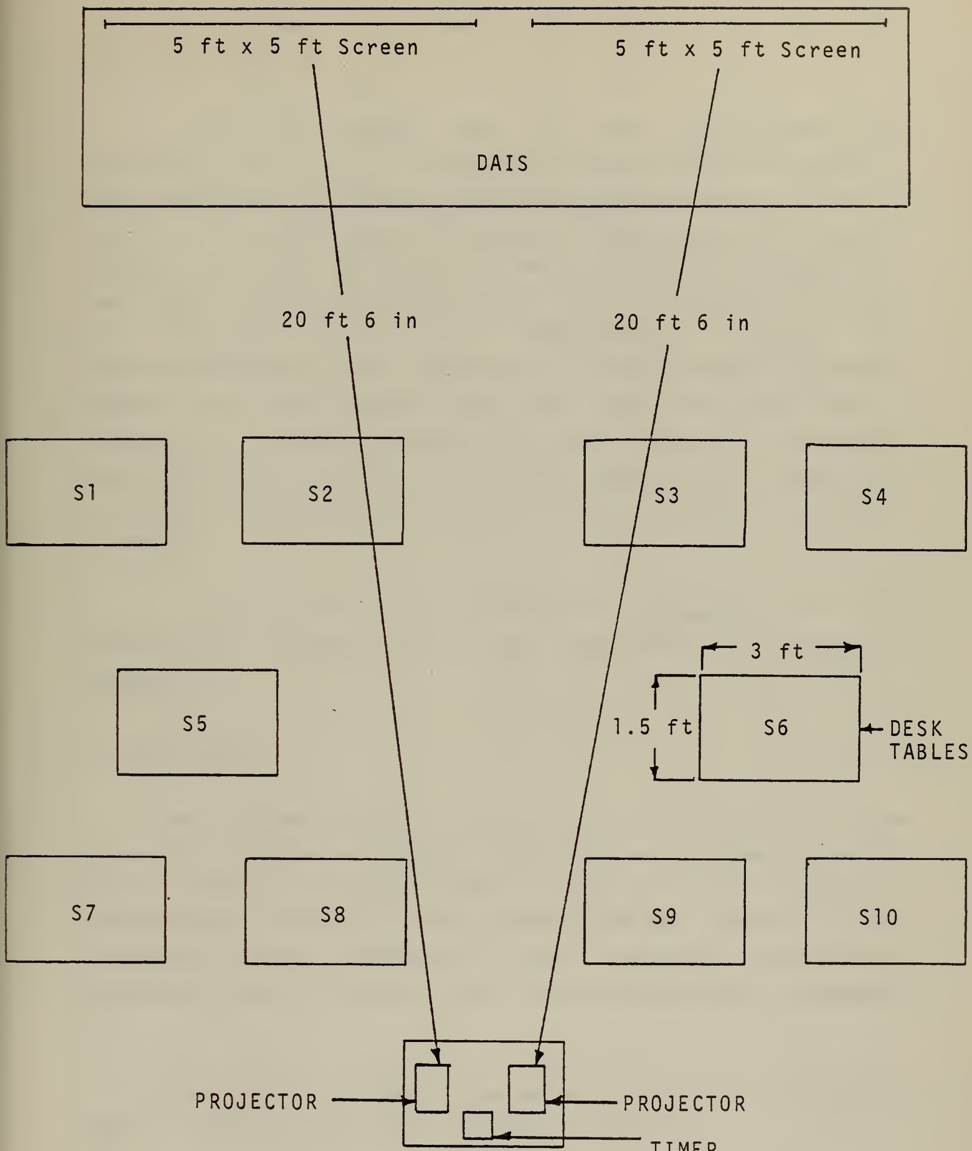


Figure 3. Physical Layout

5. The total number of slides used for this experiment was 134.

6. The imagery used in this experiment was validated by 3 U. S. Army Officers currently involved in the camouflage and target-background studies being done at the U. S. Army Combat Developments Experimentation Command (CDEC), Fort Ord, California. These Officers participated in the Army Small Arms Requirement Study II (ASARS II). ASARS II utilized the SIAF Vegetation Classes as target-backgrounds for determining actual target detection times in the field. Each Officer was shown 26 slides used in Phase 2 and asked to identify the SIAF Class he thought was depicted. Only 3 of the 26 slides shown were identified incorrectly by the 3 officers, for a 96% agreement among the 3 judges.

A description and pictorial examples of the photographic imagery used in the experiment is shown in Appendix A.

E. PROCEDURE.

Ten subjects (half of the group) were tested at a time in order to optimize viewing positions, and to determine if there was any learning effect in Phase 2 of the experiment. Subjects were briefed on the purpose and the scope of the study and were subsequently read explicit instructions concerning their judgment tasks. (See Instructions Appendix B).

Each group of subjects was shown 56 pairs of stimuli in Phase 1 and 26 individual stimuli in Phase 2.

During Phase 1 each stimulus pair was shown for 15

seconds which was adequate time for subjects to respond, with a blank slide every 10th slide to ease marking Data Sheet 1 (See Appendix C), and to reduce fatigue on the subjects. During Phase 1, slides were presented in a prearranged random order, with the restriction that neither member of a stimulus pair occur on two consecutive trials. Right and left slide positions were counterbalanced over trials.

Each SIAF Class was paired with every other SIAF Class twice. Pairs of the same SIAF Class were not allowed since it was assumed that this condition would result in a proportion of 0.50.

Prior to the conduct of Phase 2, Data Sheet 1 was collected and Data Sheet 2 (See Appendix D) was distributed to the subjects. Each subject was shown a representative slide of each of the 8 SIAF Classes (each slide was shown for 1 minute), and received a verbal description of the specific factors that constitute each of the 8 SIAF Classes. In conjunction with the visual and verbal descriptions a matrix of SIAF Class description was included on Data Sheet 2 (see Appendix D), for use by each subject in evaluating stimuli in Phase 2.

Phase 2 photographic stimuli were presented at 30 second intervals, which was adequate time for subjects to study the stimulus and respond. Slides were presented in a prearranged random order, with the restriction that no stimulus occur on two consecutive trials.

Each SIAF Class was represented by 3 distinct and different sites. SIAF Class 3 (See Figure 2) photographic imagery was taken at Hunter-Ligget Military Reservation. These site locations had previously been classified by TRW Study (1953). These 2 scenes were included for statistical

consistency tests (discussed later). The order of slide presentation was changed to determine if there was any learning effect in Phase 2. Slides 1 - 13 were interchanged with slides 14 - 26 for Group 2.

Questions were fielded by the experimenter and answers confined to the definition of each task and the explanation of specific SIAF Classes. Questions asked that were not relevant to the experiment were answered following the conduct of the experiment. Specific and relevant questions regarding the experiment that were posed by group 1 were noted and presented to group 2.

IV. RESULTS

The data analyses performed are those which are important for obtaining the desired interval scale of SIAF Classes and to determine how well an individual can utilize the existing SIAF Classes to classify vegetation.

The data obtained in Phase 1 of the experiment was analyzed using the paired comparison responses as the basis for evaluation. A summary of the paired comparison responses by SIAF Class is presented in Table 1. The number of subjects used in Phase 1 was 20. The total number of responses for each subject was 56. In general, the findings of Phase 1 indicate that judgments on intervisibility reflect an acceptable interval scale. No scores are shown for the diagonal of the matrix because the same SIAF Class was not paired with itself.

TABLE 1

Win / Loss Matrix of Responses by SIAF Class

SIAF Class	Stimulus 1	2	3	4	5	6	7	8
1	-	40	39	34	36	40	40	39
2	0	-	23	23	31	37	37	37
3	1	17	-	29	35	36	34	36
4	6	17	11	-	28	39	40	37
5	4	9	15	2	-	40	31	36
6	0	3	4	1	0	-	9	9
7	0	3	6	0	9	31	-	22
8	1	3	4	3	4	31	18	-

The Normal Deviate Table (Table 2) was constructed from Table 1 and the interval scale (Figure 4) was then derived. A wide separation is apparent in scale values between open terrain (0.00) and moderate forest (2.79). Scale values near the center of the distribution have less striking differences but distinctions among scenes in the middle of the continuum can be detected. The interval scale is based on the subject's judgment of intervisibility with (0.00) being the least difficult to see through and (2.79) being the most difficult to see through.

TABLE 2

Normal Deviate Table of Win / Loss Matrix

Stimulus

SIAF Class	1	2	3	4	5	6	7	8
1	-		+1.96	+1.04	+1.28			+1.96
2		-	+.19	+.19	+.75	+1.44	+1.44	+1.44
3	-1.96	-.19	-	+.59	+.32	+1.28	+1.04	+1.28
4	-1.04	-.19	-.59	-	+1.65	+1.96		+1.44
5	-1.28	-.75	-.32	-1.65	-		+.76	+1.28
6		-1.44	-1.28	-1.96		-	-.76	-.76
7		-1.44	-1.04		-.76	+.76	-	+.13
8	-1.96	-1.44	-1.28	-1.44	-1.28	+.76	-.13	-
$\sum x_i$	-6.22	-5.45	-2.63	-3.23	+1.96	+6.20	+2.35	+6.77
$\bar{x}$	-1.55	-.91	-.38	-.54	+.33	+1.24	+.47	+.97
Final Scale	.00	.64	1.18	1.02	1.88	2.79	2.03	2.52

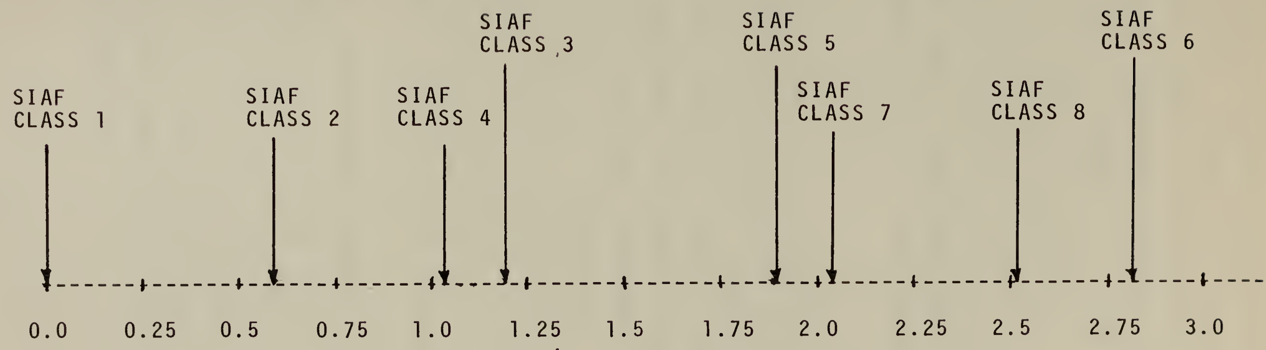


Figure 4. Interval Scale of SIAF Classes

Detailed graphics for the distributions of judgments for the paired comparison scores are presented in Figures 5 through 12. Figures 5 and 10 are relatively flat compared with the other figures and therefore indicate the 2 extremes on the interval scale. The low number of responses in Figure 5 indicate that SIAF Class 1 was judged the least difficult and the high scores in Figure 10 indicate that SIAF Class 6 was judged the most difficult with respect to intervisibility. The remaining figures have steep slopes originating at the high scores for SIAF Class 1 and descending from that point. The other 6 SIAF Classes lie on the continuum between SIAF Class 1 and SIAF Class 6.

To determine how well an individual can utilize the existing SIAF Classification System to classify terrain in the field the theory of Information Transmission (Shannon and Weaver, 1949) was utilized. Since 8 separate stimuli were involved in the experiment, 3.0 bits of information would be transmitted if all subjects responded with the correct response, thus, 3.0 bits of uncertainity was used as the initial value of Information Transmission. Table 3 tabulates the responses made to each stimuli class. To obtain the amount of information transmitted the value calculated for each SIAF Class was subtracted from the initial value of 3.0. These transmission values are given in Table 4.

The average information transmitted for the 8 SIAF Classes was found to be 1.31 bits of information. This value (1.31) can be interpreted as 43.6% correct responses by the subjects as an average. The information transmission values range from a high of 2.78 for SIAF Class 1 to a low of 0.54 for SIAF Class 5. The determining factor of the transmission values obtained is the dispersion of the responses over the range of possible responses.

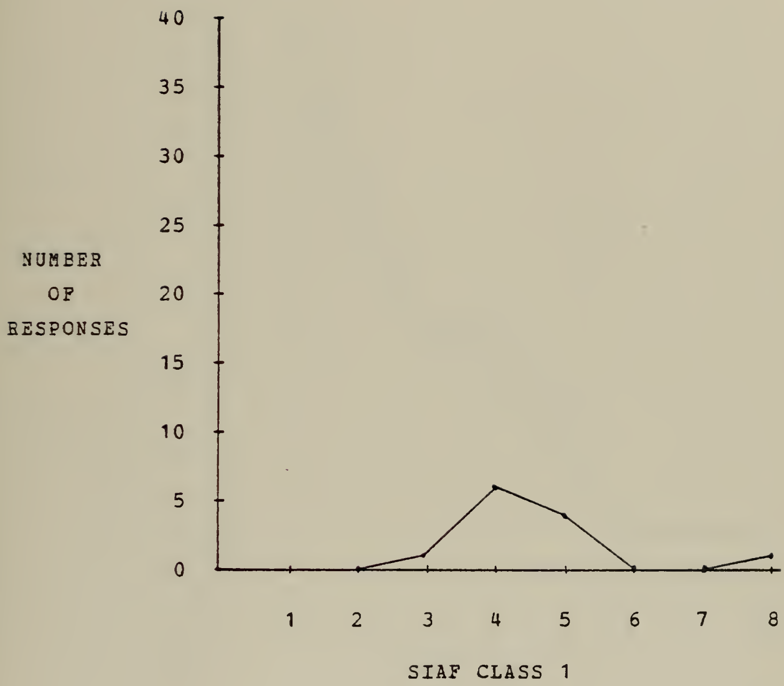


FIGURE 5. Distribution of Subjects Responses Which Judged SIAF Class 1 More Difficult

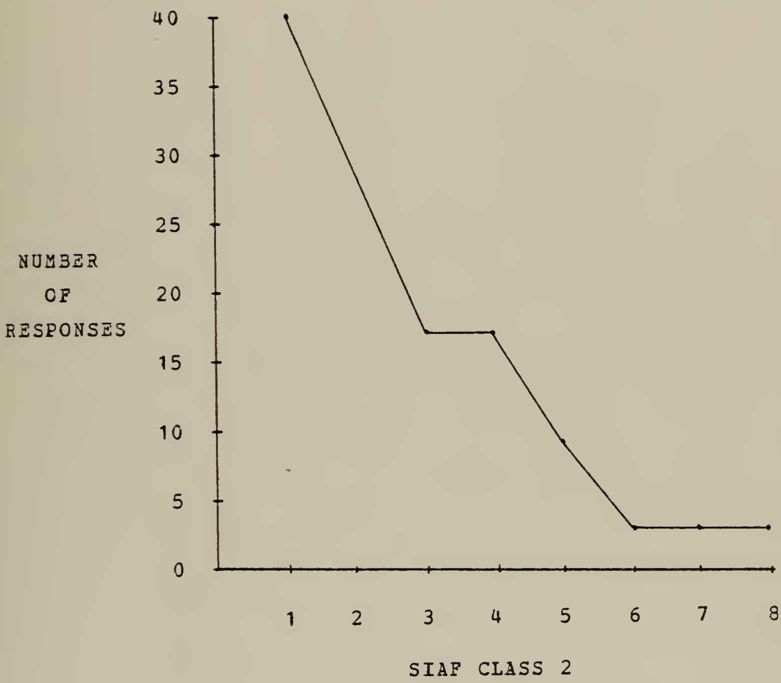


FIGURE 6. Distribution of Subjects Responses Which Judged SIAF Class 2 More Difficult

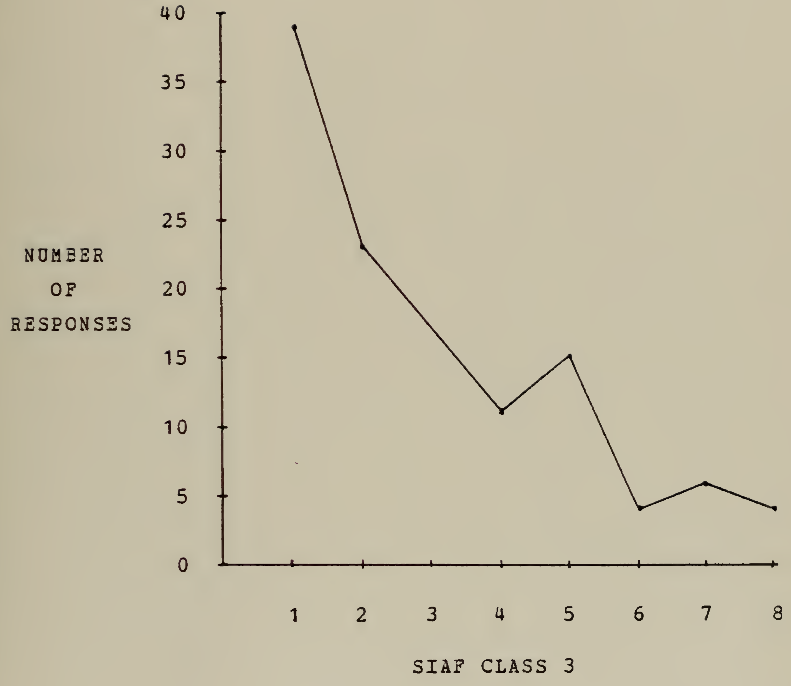


FIGURE 7. Distribution of Subjects Responses Which Judged SIAF Class 3 More Difficult

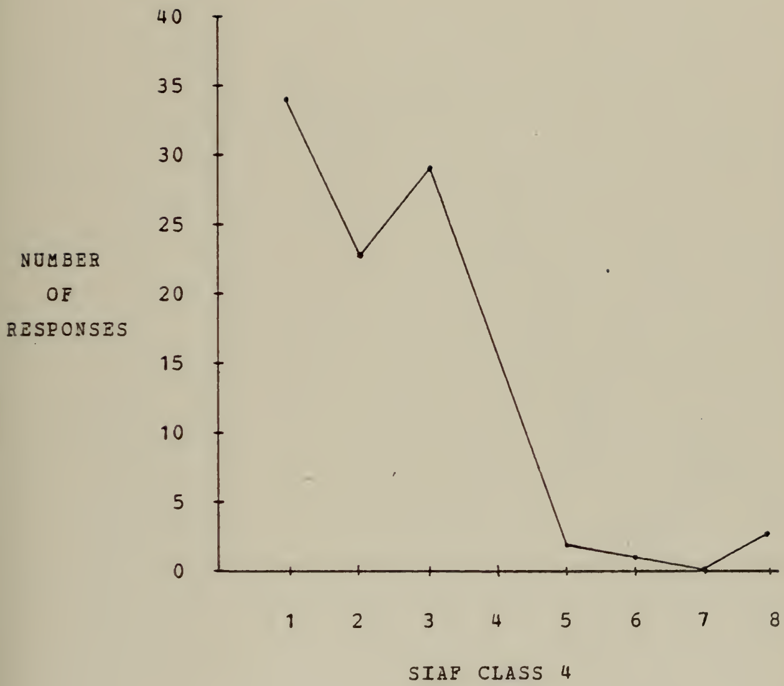


FIGURE 8. Distribution of Subjects Responses Which Judged SIAF Class 4 More Difficult

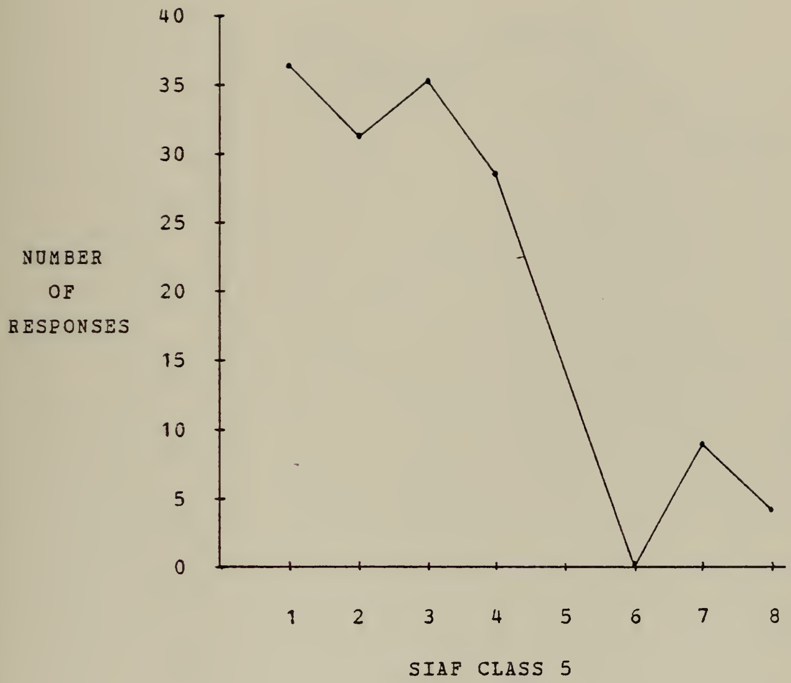


FIGURE 9. Distribution of Subjects Responses Which Judged SIAF Class 5 More Difficult

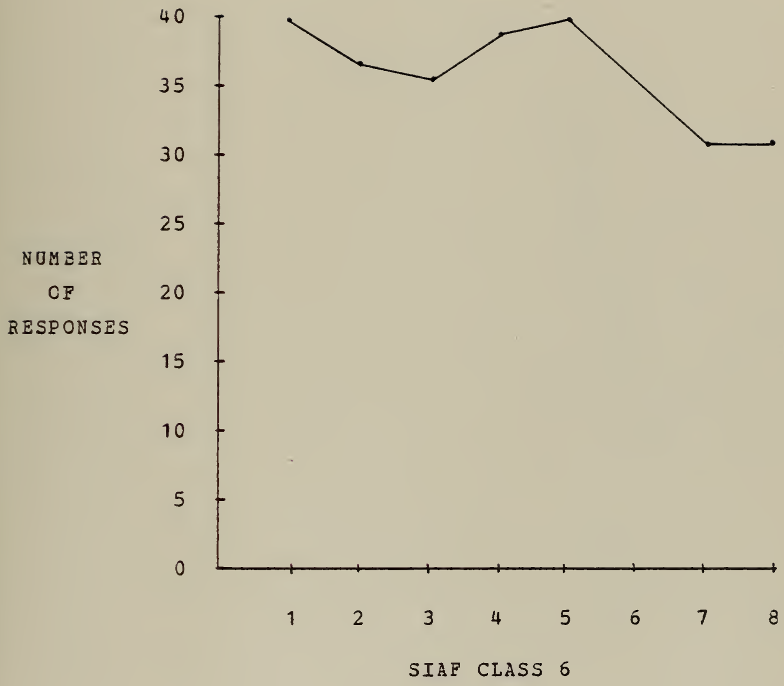


FIGURE 10. Distribution of Subjects Responses Which Judged SIAF Class 6 More Difficult

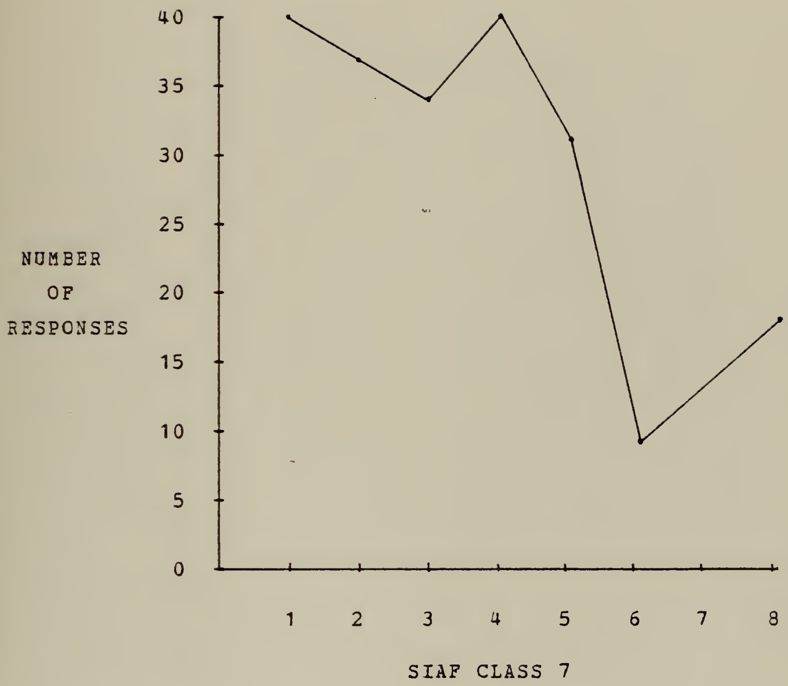


FIGURE 11. Distribution of Subjects Responses Which Judged SIAF Class 7 More Difficult

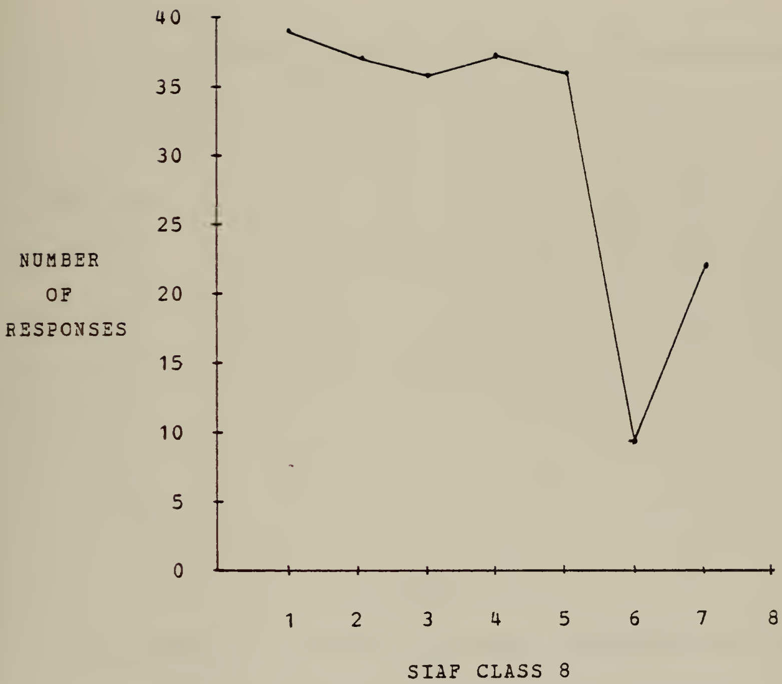


FIGURE 12. Distribution of Subjects Responses Which Judged SIAF Class 8 More Difficult

TABLE 3

Responses Made to Specific SIAF Class Stimuli

	SIAF Class	Stimulus 1	2	3	4	5	6	7	8
Response	1	58	4	1					
	2	2	42	27		2	1		12
	3		7	29	7	8	7		8
	4		6	2	38	15	10	4	24
	5		1	1	7	19	12	5	5
	6				8	7	17	18	2
	7					7	5	28	
	8					2	8	5	9

TABLE 4

Information Transmitted by Subject for Each SIAF Class

	SIAF Class 1	2	3	4	5	6	7	8
Bits of Information	2.78	2.59	1.63	1.50	.54	.58	1.11	.75

The reliability data obtained in Phase 2 of the experiment was analyzed using the Intraclass Correlation Coefficient (Haggard, 1958) to determine the average agreement between the 2 stimuli used for subject reliability. Table 5 reflects the subjects responses to the stimuli (2 slides of Hunter-Ligget) used for reliability.

TABLE 5

Distribution of Subject Responses to Reliability Stimulus (SIAF Class 3)

	SIAF CLASS	1st RESPONSE 1	2	3	4	TOTAL
2nd RESPONSE	4	1	1			2
	3		6	8	1	15
	2			3		3
	1					0
	TOTAL	1	7	11	1	20
	DIST (X + Y)	1	10	26	3	40

To measure the agreement (or disagreement) the square of the differences between paired SIAF Classes was calculated and averaged over all the subjects, then this average was divided by the total variance of the combined distribution. This solution yielded an average magnitude of disagreement between

the first slide stimulus and the second slide stimulus, in relation to the intersubject variation in scores. To determine the agreement the average of disagreement was subtracted from 1 to yield agreement among subjects.

The Intraclass Correlation Coefficient (ρ) was computed from the equation :

$$\rho = 1 - \sum_{i=1}^{4} (X_i - Y_i)^2 / 2n\sigma^2_{(X + Y)}$$

The determined (ρ) was (-.501). The fact that (ρ) was negative indicates that there is a negative correlation with respect to the subjects response to the first and second stimulus. The magnitude of (ρ) indicates that the correlation is significant. It appears that if a subject was low in his evaluation of the first slide there was a tendency for him to respond high on the second slide stimulus, or if his response was high for the first stimulus a prediction of low could be made for his response to the second stimulus.

The Pearson Correlation Coefficient was also calculated. The determined value was (-.515), which agrees with the Intraclass Correlation Coefficient of (-.501). The Pearson Coefficient is usually higher because this method does not consider the absolute differences in responses. The Pearson Correlation Coefficient is significant at the 0.01 level.

The data from Phase 2 was analyzed to determine if the subjects displayed any learning effects during the observance of the stimuli. The slide presentation was altered by reversing slide groups 1 - 13 with 14 - 26 for Group 2. This in effect allowed the experimenter to determine the increase (or decrease) in correct responses between the two sequences. Table 6 tabulates the number of correct responses by group with the different sequences.

TABLE 6

Number of Correct Responses by Group to Phase 2 Stimuli

Stimuli Sequence	Group 1		Group 2	
	1 - 13	14 - 26	1 - 13	14 - 26
Number of Correct Responses by Subject	6	4	8	6
	8	6	5	5
	6	4	7	4
	5	5	6	7
	5	3	4	6
	4	5	7	3
	5	5	8	6
	9	6	4	6
	11	12	5	7
	5	4	4	8
Total	64	54	58	58

To determine if there was any learning effects the Analysis-of-Variance for one variable was used. The hypothesis tested was that the means from each sequence of the photographic stimuli were equal. A significance level of 0.05 was used to test the hypothesis. If the means were equal this would indicate that there was no learning in the observance of the stimuli. The analysis-of-variance results are shown in Table 7.

TABLE 7

One Way Analysis-of-Variance of Correct Responses
by Group to Phase 2 Stimuli

	Sum of Squares	DF	Mean Square	F Ratio
Sequence Means	5.1	3	1.7	.45
Within	137.0	36	3.80	
Total	142.1	39	3.64	

The hypothesis that the means of the 4 sequences of the photographic stimuli were equal was accepted since the observed F Ratio (0.45) is less than the $F_{.95}$ (3,36) = 2.89. Since the sequence means were equal there was no indication of learning during Phase 2 of the experiment.

V. DISCUSSION

In general, the findings of the Intervisibility Phase of the experiment indicate that judgments on this dimension reflect an acceptable scale discrimination. The interval scale obtained differs from the ordinal scale devised for the SIAF Model. The finding that SIAF Class 6 was judged most difficult is interesting. One reason for this rating could be the angle that the photographic stimulus was taken from. It should be noted here that the stimulus had very dense brush which could have influenced the judgments of the subjects to rate it as most difficult. The combination of the dense brush and the relatively dense trees could have biased the responses with respect to intervisibility.

The reversal of SIAF Class 3 and SIAF Class 4 on the interval scale is a difficult result to explain. It could be due to the fact that the photographic stimulus for SIAF Class 3 appeared as very dense growth and it was difficult to determine the height of the vegetation. A tree was included in the slide to aid the subjects in determining the height of the vegetation, but this aid was not spotted by a majority of the subjects when questioned later as to why they judged SIAF Class 3 more difficult than SIAF Class 4. The vegetation in SIAF Class 3 was 3-5 feet high and was judged in many cases by the subjects to be considerably higher. Since the vegetation was only 3-5 feet high it would not interfere with intervisibility with respect to a standing man.

The extremes of the interval scale reflect distinct differences in the SIAF Classes while the center of the scale is not as definitive. This tends to substiantiate the fact that discrimination at the extremes is less difficult than at the center of the scale.

The results of Phase 1 tend to indicate that the

Vegetation Classification Scheme devised for the SIAF Model has merit and that it is an adequate scale.

In determining the amount of information that was transmitted during Phase 2 of the experiment, utilizing the Information Transmission technique, results indicate that only 43% of the information was transmitted by the subjects. This indicates that the subjects had difficulty in determining the correct SIAF Class when presented stimuli. For an individual to classify terrain in the field it will be necessary to train him extensively to obtain a high percentage of reliability. This study indicates that even with visual aids individuals could not differentiate SIAF Classes with acceptable accuracy. It was pointed out that the photographic stimuli used throughout Phase 2 of the experiment was verified, with 96% accuracy, by individuals who are familiar with the SIAF Classification Scheme.

The data indicates that subjects had little difficulty in correctly identifying SIAF Classes 1 and 2. As the stimulus scene increased in complexity the transmission values decreased. The dispersion of responses for SIAF Classes 5 - 8 substantiate the fact that the subjects had difficulty in determining the correct response.

One observation derived from the data (Table 3) is that 66% of the subjects when shown SIAF Class 8 responded that it was SIAF Class 4. The other seven SIAF Classes (1-7) data points indicate that the greater number of subjects responded with the correct response. It is interesting to note that even with the large number of incorrect responses SIAF Class 8 still was not the lowest with respect to information transmitted.

The photographic stimuli were reexamined to establish if there were any reasons for the results obtained. No

conclusions could be made as to why SIAF Claases 5, 6, and 7 transmission values were so low.

The photographic stimuli included for determining the agreement (reliability) of the subjects had been previously classified by TRW in the origional test of the SIAF Model. The results of this part of the study are hard to explain. The response data (Table 5) indicates that subjects confused the characteristics of SIAF Class 2 and SIAF Class 3. Only 40% of the subjects responded correctly to both stimuli. The only difference between SIAF Class 2 and SIAF Class 3 is the density of the type of vegetation. Trying to differentiate between 300 and 500 bushes per 50 meter by 50 meter square is difficult. This difference is not very subtle and when looking at the criteria for classifying vegetation in the SIAF Model, it appears that the discrimination in these 2 classes is not as pronounced as the other classes.

The result that the Intraclass Correlation Coefficient was negative indicates that a negative correlation exists. This means that if a subject's response to the first stimulus was low there was a tendency for him to respond high to the second stimulus, or if he responded high to the first stimulus a prediction of low could be made for the second stimulus. Given that a subject made the correct response on the first stimulus no prediction could be made with any validity as to what his second response would be. The magnitude (.501) indicates that the correlation coefficient is significant.

It was hypothesized that the subjects would display a learning process during the conduct of the experiment. This hypothesis was found to be false when the data was analyzed. In fact, Group 1 recorded 10 fewer correct responses in sequence 2 than in sequence 1. Six out of ten subjects in Group 1 recorded lower scores in sequence 2 than they had in sequence 1. All 10 subjects in Group 1 were questioned after

the experiment had been conducted as to why they found sequence 2 more difficult. All but 1 subject replied that after observing the stimuli it became more difficult to differentiate as the experiment progressed. This indicates that as the sample size increased they found it harder to decide which class was being shown. The subject which achieved the high scores (See Table 6) was a U. S. Army Student and had been involved in the camouflage and target-background area recently. This further substantiates the observation that extensive training is needed to obtain results that have acceptable accuracy in individual judgments. Group 2 responded with an equal number of correct discriminations for both sequences.

To evaluate the results of Phase 2 a one-way analysis-of-variance (ANOVA) was used to test the hypothesis that the means of the 4 sequences were equal. The observed F Ratio was 0.45 which is less than the theoretical F Ratio of 2.89, indicating that the means were equal with a significance level of 0.05 (See Table 7).

No explanation can be made for the absence of learning in the experiment, or for the case of Group 1 which displayed a negative learning by decreasing its total correct responses for the second sequence.

It was very difficult to find and correctly classify photographic stimuli for the conduct of the experiment. As it was 4 classes had to be deleted from the experiment because the densities and type of vegetation could not be located in the area. The study has shown that a critical element in the classification process is the observers position relative to the terrain. It appears that the deviations of this study's interval scale from the SIAF Model scale may have been caused by the position from which the specific photographic stimuli were taken.

VI. SUMMARY

The two objectives of the study were accomplished with satisfactory results. The interval scale created by subjective judgments on intervisibility closely paralleled the ordinal scale adopted in the SIAF Model. There were two notable differences in the scales:

1. SIAF Class 3 was judged more difficult than SIAF Class 4.

2. SIAF Class 6 was judged as most difficult of all the SIAF Classes. It should be noted that the ordinal scale in the model is based upon density and type of vegetation while the interval scale determined by this study is based upon intervisibility.

These deviations were studied and the conclusion was reached that they occurred as the result of the angle at which the photographs were taken. In both cases the subjects responded with the stimuli as being more difficult. These deviations from the ordinal scale point out the fact that individuals perceive landscapes differently based upon their judgments. Further study in this area is recommended to examine how individuals rate various combinations of density and types of vegetation. What is judged as very difficult by one individual may be judged as easy by another individual. This type problem was not addressed in this study.

The data amplifies the fact that subjects with relatively little prior training obtained fairly low scores with respect to accuracy. The average of 43% is not an acceptable level of accuracy. Subjects displayed confusion when required to differentiate between 8 SIAF Classes. The effect of utilizing all 12 SIAF Classes should be examined.

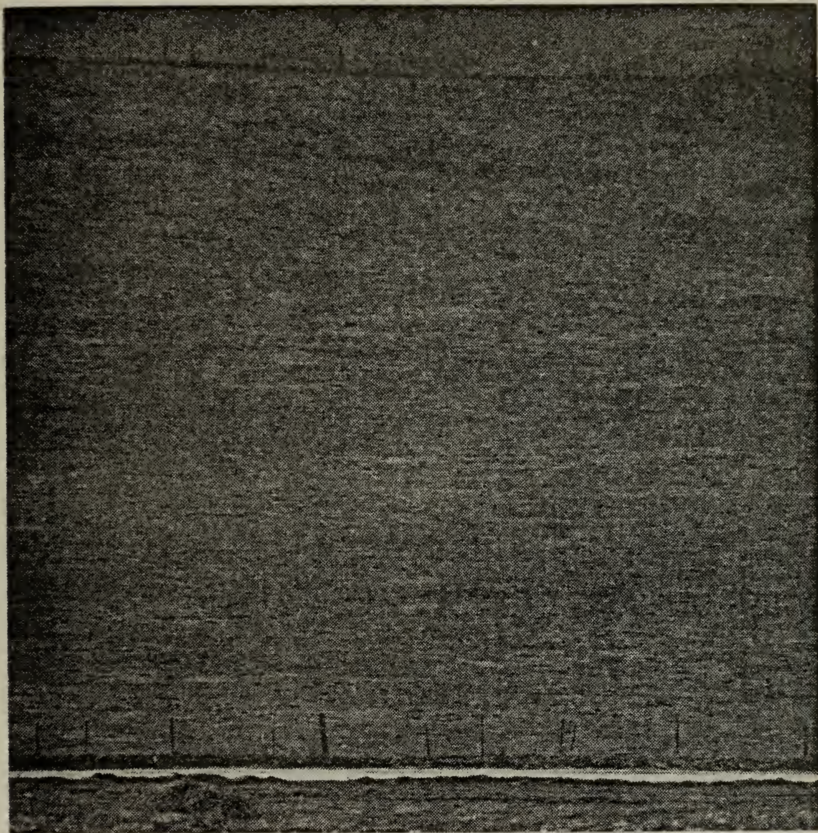
What effect will the increase in number of stimuli have on the accuracy? In order to obtain usable data from the SIAF Model the inputs must reflect the situation that is being modelled. Those personnel responsible for data inputs to the SIAF Model will have to be trained prior to requiring them to evaluate landscapes.

It was expected that as the subjects progressed through the experiment they would experience some learning effects with respect to the SIAF Classes. This was not the case and as Group 1 progressed they in fact, decreased the number of correct responses.

Overall, the experiment pointed out that individuals judge landscapes differently even when aided with written characteristics of the scales being judged. This judgment difference may be decreased to an acceptable level with training. Results of this study demonstrated that photographic scenes could be scaled on dimensions related to the visual complexity of target-backgrounds. The measures obtained through subjective scaling indicated a high degree of measurement reliability and scale discrimination.

APPENDIX A

PHOTOGRAPHIC STIMULI

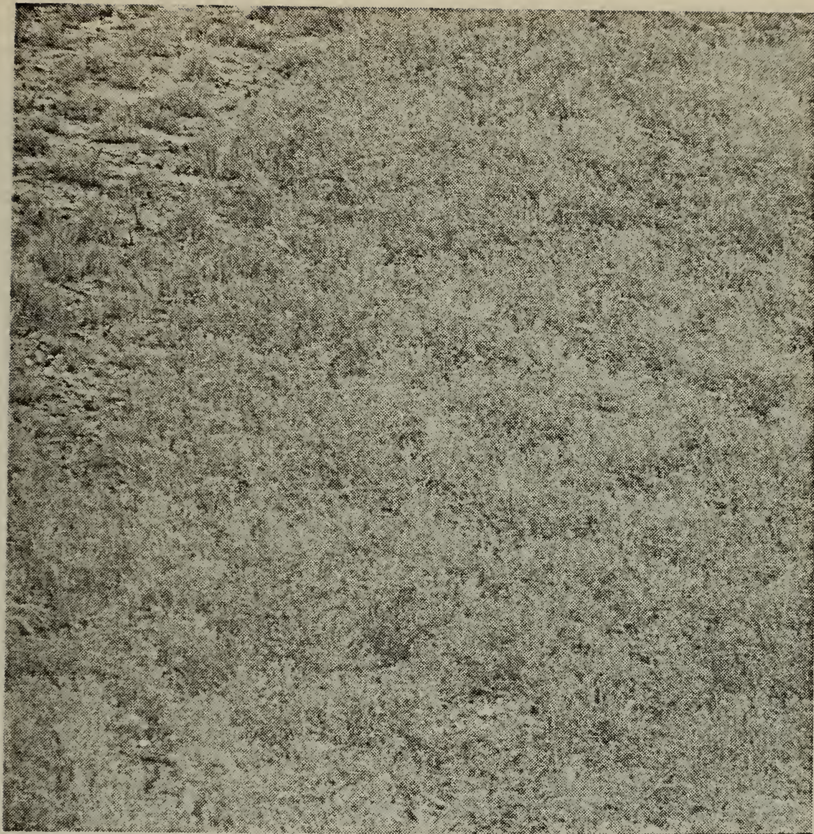


SIAF CLASS 1

FEATURE	DENSITY per 50m x 50m	WIDTH (meters)	HEIGHT (meters)	DESCRIPTION
None	0	0	0	Open

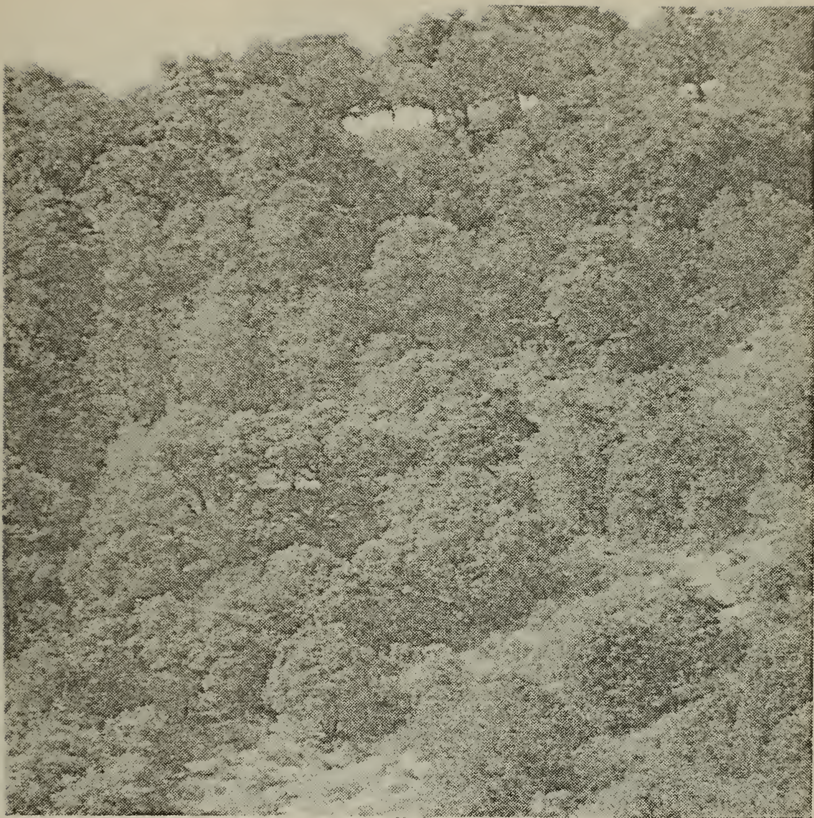
SIAF CLASS 2

FEATURE	DENSITY per 50m x 50m	WIDTH (meters)	HEIGHT (meters)	DESCRIPTION
Grass or Brush	300	1.0	1.0	Sparse Grass



SIAF CLASS 3

FEATURE	DENSITY per 50m x 50m	WIDTH (meters)	HEIGHT (meters)	DESCRIPTION
Grass or Brush	500	1.5	1.5	Moderate Grass



SIAF CLASS 4

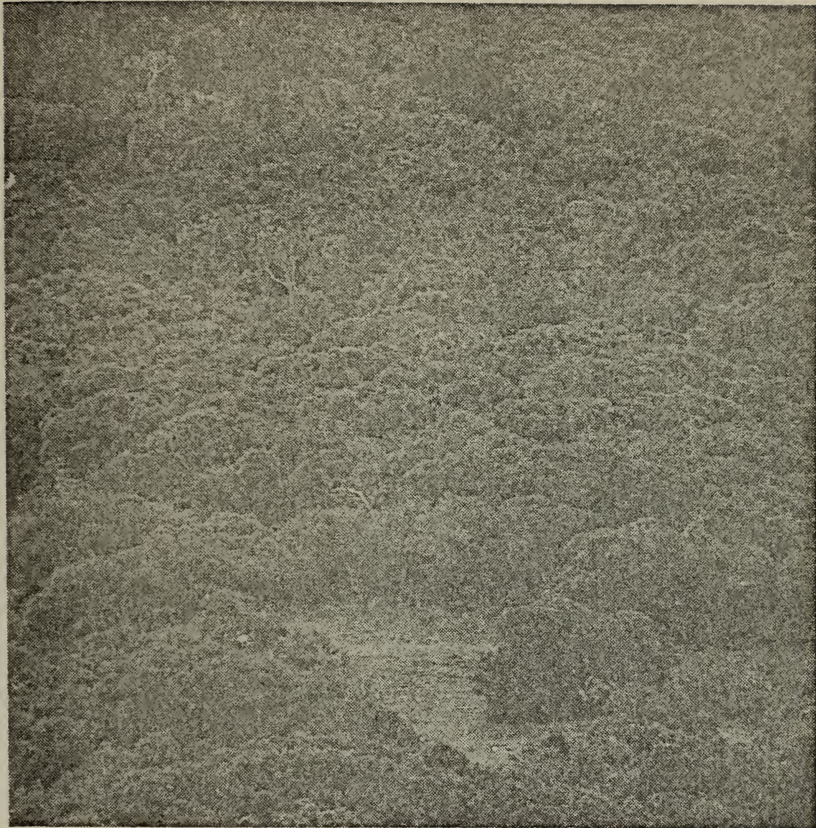
FEATURE	DENSITY per 50m x 50m	WIDTH (meters)	HEIGHT (meters)	DESCRIPTION
Grass	0	0	0	Light Forest
Brush	63	2.0	3.0	With Brush
Trunk	42	0.3	2.0	
Crown	0	3.0	10.0	

SIAF CLASS 5

FEATURE	DENSITY per 50m x 50m	WIDTH (meters)	HEIGHT (meters)	DESCRIPTION
Grass	0	0	0	Sparse
Brush	150	1.0	1.0	Forest
Trunk	84	0.3	3.0	
Crown	0	3.5	12.0	

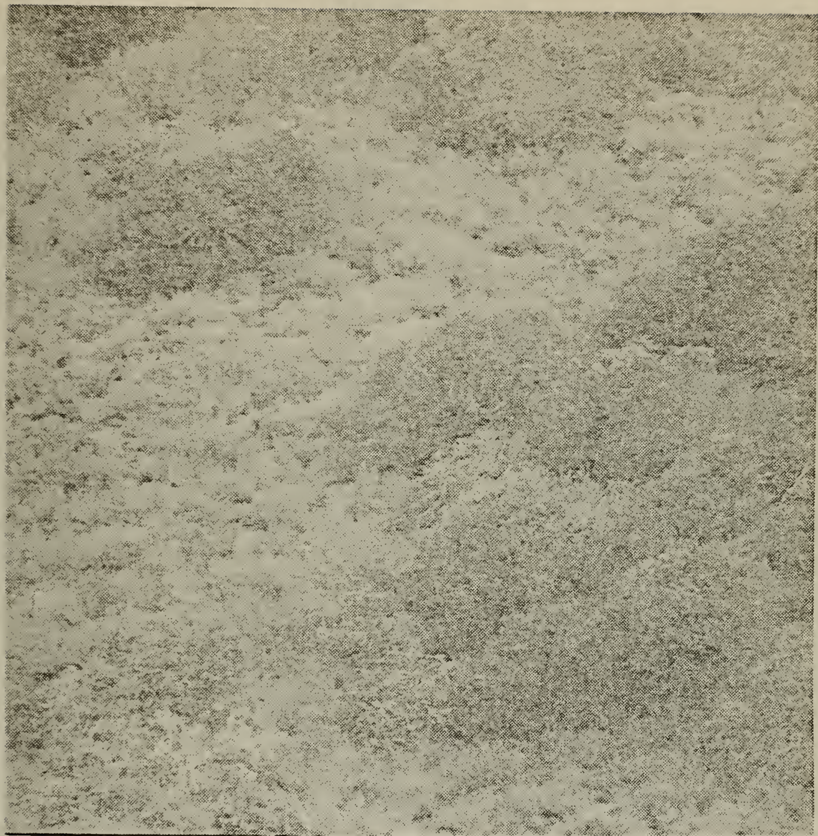
SIAF CLASS 6

FEATURE	DENSITY per 50m x 50m	WIDTH (meters)	HEIGHT (meters)	DESCRIPTION
Grass	0	0	0	Moderate
Brush	300	1.0	1.0	Forest
Trunk	180	0.3	5.0	
Crown	0	4.0	15.0	



SIAF CLASS 7

FEATURE	DENSITY per 50m x 50m	WIDTH (meters)	HEIGHT (meters)	DESCRIPTION
Grass	0	0	0	Heavy
Brush	0	0	0	Forest
Trunk	360	0.45	9.0	
Crown	0	4.5	20.0	



SIAF CLASS 8

FEATURE	DENSITY per 50m x 50m	WIDTH (meters)	HEIGHT (meters)	DESCRIPTION
Grass	0	0	0	Dense Brush
Brush	720	2.0	2.5	With Trees
Trunk	18	0.2	1.0	
Crown	0	4.0	15.0	

APPENDIX B

INSTRUCTIONS READ TO SUBJECTS

In 1968 the Advanced Research Projects Agency in conjunction with the U.S. Army Infantry School determined the need for a Small Independent Action Force (SIAF) Model. The need was a result of the type of action that took place in Vietnam i.e., small patrol type action. A component of the model was a set of vegetation classes to define intervisibility.

The purpose of this experiment is twofold. First, is to obtain an interval scaling of the SIAF Vegetation Classes. The second purpose is to obtain information on how well an individual can make use of the SIAF Classes for classifying terrain. In conjunction with this the reliability of judges will be checked.

You will be looking at slides of various vegetation types (grass, brush, trees) and different vegetation densities. All slides were taken from ground level and at a distance of 300-350 meters. There are no aerial views of distant terrain.

When looking at a slide, determine its characteristics from the center of the slide. I have attempted to give you indicators to assist you in the evaluation of the slides by placing aids on the edges of the slides. There may be a tree or an open area to aid in the determination of the height and type of vegetation.

Let me tell you again to look at the center of the slide for determining characteristics.

Are there any questions ?

The first part of the experiment consists of 56 pairs of slides. I am now passing out Data Sheet 1. Please put your

name in the upper right hand corner. As you can see there are columns marked RIGHT and LEFT. These columns correspond to the RIGHT and LEFT screens before you. Notice that the answer blocks are divided into groups of 5. Every 10 slides there will be a blank slide which will be on for 15 seconds. During those 15 seconds I will announce the slide pair which will follow.

Are there any questions ?

The task you are to perform in Phase 1 is to identify which scene (RIGHT or LEFT) is most difficult to see through. The criterion to use on each pair, is can I see a stationary standing man through the vegetation.

Let me remind you to look at the center of the slide to determine the characteristics. The edges of the slide will give you aids in determining the height and type of vegetation.

Are there any questions ?

(Slides every 15 seconds)

Please turn in Data Sheet 1.

I am now handing out Data Sheet 2. Please put your name in the upper right hand corner of Data Sheet 2.

The purpose of phase 2 is to determine how well you can use the 8 SIAF Vegetation Classes in discriminating terrain. I will show you a representative slide of each SIAF Class and while the slide is on I will give you a verbal description of that class. Look at the bottom of Data Sheet 2. You will see a matrix of the 8 SIAF Classes. During the familiarization

slides attempt to coordinate the visual scene on the screen before you with the data in the matrix.

Are there any questions ?

Your task for Phase 2 is to identify the SIAF Class for the slide shown. Remember to determine the characteristics of the slide from the center of the slide. There are aids on the edges of the slides to assist you in evaluation the height and density of vegetation.

SLIDE 1. SIAF Class 1

No appreciable vegetation

Open terrain

SLIDE 2. SIAF Class 2

Grass and brush, about 300 per 50 x 50 meter square.

Sparse Grass

SLIDE 3. SIAF Class 3

Grass or brush, about 500 per 50 x 50 meter square

Moderate grass

SLIDE 4. SIAF Class 4

No grass, Brush about 63 and trees about 42 per 50 x 50 meter square

Light forest with brush

SLIDE 5. SIAF Class 5

No grass, about 150 bushes, and 84 trees per 50 x 50 meter square

Sparse forest

SLIDE 6. SIAF Class 6

No grass, about 300 bushes and 180 trees per 50 x 50 meter square

Moderate forest

SLIDE 7. SIAF Class 7

No grass or bushes and about 360 trees per 50 x 50 meter square

Heavy forest

SLIDE 8. SIAF Class 8

No grass, about 720 bushes and 18 trees per 50 x 50 meter square

Dense brush with trees

Now that you have seen representative scenes of the 8 SIAF Classes are there any questions ?

Remember that your task is to identify the SIAF Class that you think is depicted in each scene presented.

Each slide will remain on for 30 seconds, during this time you are to look at the scene presented, identify the SIAF Class that you think is depicted in the scene, and mark the SIAF Class number in the appropriate box. The matrix at the bottom of the Data Sheet is for your use in determining the SIAF Class.

Remember to determine the SIAF Class from the center of the slide.

Are there any questions ?

Slides at 30 second intervals

Collect Data Sheet 2.

APPENDIX C

DENSITY EXPERIMENT DATA SHEET - 1

	Left	Right		Left	Right		Left	Right
1	☐	☐	21	☐	☐	41	☐	☐
2	☐	☐	22	☐	☐	42	☐	☐
3	☐	☐	23	☐	☐	43	☐	☐
4	☐	☐	24	☐	☐	44	☐	☐
5	☐	☐	25	☐	☐	45	☐	☐
6	☐	☐	26	☐	☐	46	☐	☐
7	☐	☐	27	☐	☐	47	☐	☐
8	☐	☐	28	☐	☐	48	☐	☐
9	☐	☐	29	☐	☐	49	☐	☐
10	☐	☐	30	☐	☐	50	☐	☐
11	☐	☐	31	☐	☐	51	☐	☐
12	☐	☐	32	☐	☐	52	☐	☐
13	☐	☐	33	☐	☐	53	☐	☐
14	☐	☐	34	☐	☐	54	☐	☐
15	☐	☐	35	☐	☐	55	☐	☐
16	☐	☐	36	☐	☐	56	☐	☐
17	☐	☐	37	☐	☐			
18	☐	☐	38	☐	☐			
19	☐	☐	39	☐	☐			
20	☐	☐	40	☐	☐			

APPENDIX D

DENSITY EXPERIMENT DATA SHEET - 2

1		14	
2		15	
3		16	
4		17	
5		18	
6		19	
7		20	
8		21	
9		22	
10		23	
11		24	
12		25	
13		26	

CATEGORY	SIAF CLASS	FEATURE	DENSITY PER 50m x 50m	DESCRIPTION
Low	1	--	--	Open
	2	Grass or Brush	300	Sparse Grass
	3	Grass or Brush	500	Moderate Grass
Medium	4	Grass Brush Trunk	0 63 42	Light Forest with Brush
	5	Grass Brush Trunk	0 180 84	Sparse Forest
High	6	Grass Brush Trunk	0 300 180	Moderate Forest
	7	Grass Brush Trunk	0 0 360	Heavy Forest
	8	Grass Brush Trunk	0 720 18	Dense Brush with Trees

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